Temperature in control

A new generation of durable inverters that are able to measure and control temperature changes are enabling the expansion of electrified vehicle development

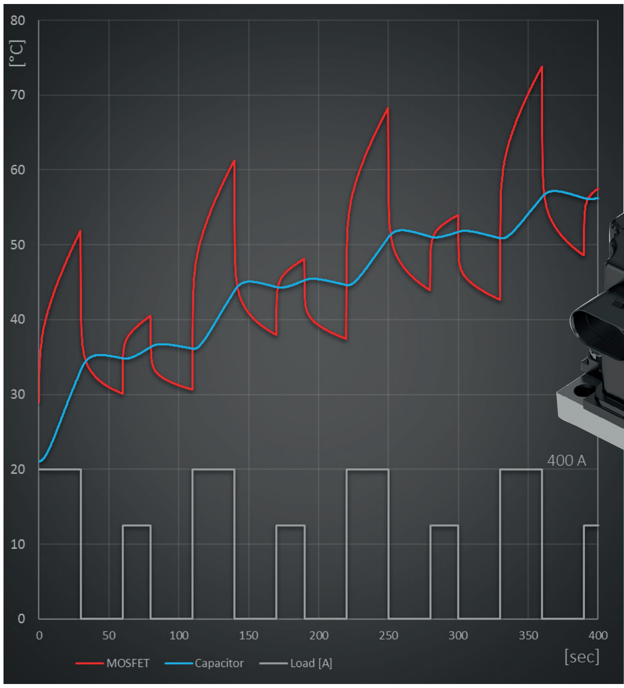
In the wake of the electrification of the passenger car, a multitude of other applications have started to adopt the notion of zero emissions. However, a variety in applications also means a variety in requirements for the respective motor and controller systems.

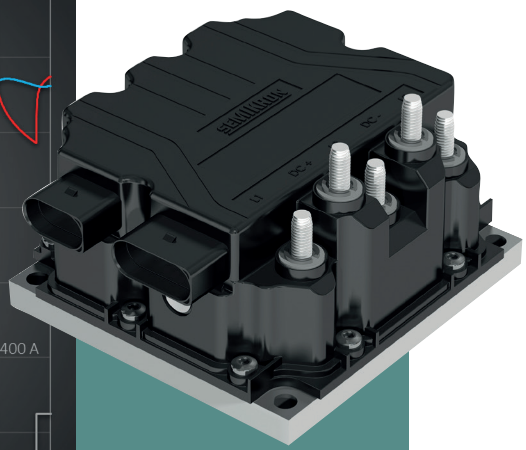
Solutions for automotive or industrial full-electric driving, P0-P4 mild-hybrid systems or hydraulic pumps for example have vastly different requirements, which cannot simply be expressed by an overall kW value. The inverter-controller functionality must match the overall vehicle-control structure, power-ratings and lifetime vehicle operating conditions.

Temperature is key to understand, predict, control and balance power and lifetime – especially the repetition of temperature changes of the power-switches, which have the strongest impact on thermal stress and thus define product lifetime.

The dependency of being long lasting in spite of temperature changes is very strong and highly nonlinear. Errors in measurement and estimation of temperatures of a few degrees will result in very large differences between the real and estimated lifetime. Leading to either oversized and costly inverters or overstressed systems not reaching their planned lifetimes.

Accurate thermal models that can simulate temperatures in a system are therefore necessary in the design-phase to optimize the integration of the inverter in the overall vehicle system – balancing output power against lifetime and cooling. The same models are also needed later on in the regular operation to calculate critical system temperatures based on the measurable temperatures and also load conditions.





The SKAI3 low-voltage inverter is designed for battery voltages ranging from 48V to 144V DC

For the SKAI3 LV, a thermal model has been derived that can predict temperatures of the power switches and the capacitors, depending on cooling conditions and load conditions. Even with rapid steps in the output current as shown in the diagram, an accuracy of more than 2°C after 400 seconds compared to the measurement is achieved. This allows the evaluation of required ambient and cooling conditions and a prediction of the achievable lifetime for any kind of load cycle.

With the same basic model, in-operation temperature calculation is possible even for highly dynamic conditions, such as load steps, where reference temperatures from a separate sensor would be too slow and inaccurate.

A Foster-model approach is used as mathematical formalism, making it easy for the user to implement a precise thermal calculation in the system control-loop.

The upcoming SKAI3 LV, the third generation of Mosfet-based inverters, offers high power in a very small volume, while leaving maximum flexibility for system integration. Supported by models for power-loss and temperature calculation, a wide range of applications can be addressed.

The SKAI3 LV is a compact powercore, which needs a control-board to be completed. With a power-density of more than 25kVA/l and a total volume of less than 1.8l, the design already fits into many applications with its standard case. For designs with special requirements regarding space, cooling or power-connectors, the design suits as a perfect starting point for a customer specific design.

The interface between customer controller and gate-driver has an easy-to-use structure and requires only a single 13V supply. Fed back control signals are already voltage-scaled, while current and temperature sensors are routed to a separate connector to maintain electrical isolation.

To simplify controller and software design, a dedicated housing is available, providing easy access to the controller-PCB in design, while already using the power section in its full functionality and performance.

The SKAI3 LV product family is designed for battery voltages with a wide range of input voltages, ranging from nominal 48V up to 144V DC covering all typical batteries in industrial applications and other vehicle applications.